TARTARUS MODEL SENSITIVITY EXPERIMENT

Jerry Thomas

Army Concepts Analysis Agency
Bethesda, Maryland

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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

5125 MOSTERT AVENUE

BETHESDA, MARYLAND 20014

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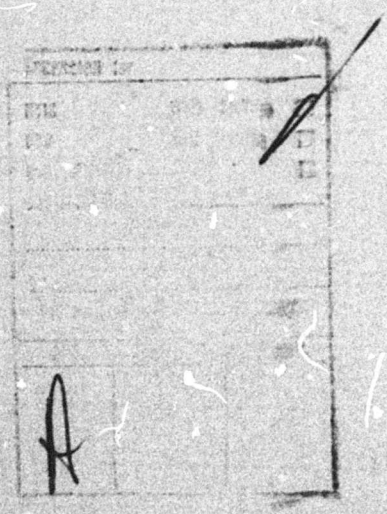
Commander
USA Concepts Analysis Agency
ATTN: Director of Methodology and Resources
8120 Woodmont Avenue
Bethesda, MD 20014



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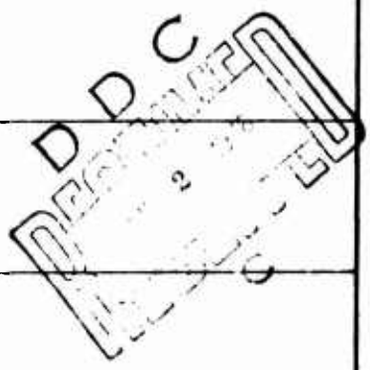

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

TARTARUS is a firepower potential dependent, ground combat theater model that simulates, at a high level of aggregation, the interactions of combat units in contact. A sensitivity experiment, using a factorial experimental design, was performed on the TARTARUS model. Model design, factor inputs, outputs, calculations, problems, and observations are discussed.

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PREPARED BY

METHODOLOGY AND RESOURCES DIRECTORATE

US ARMY CONCEPTS ANALYSIS AGENCY

8120 WOODMONT AVENUE

BETHESDA, MARYLAND 20014

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SUMMARY

1. Facts. - The Methodology and Resources Directorate of the US Army Concepts Analysis Agency (CAA) initiated in April 1974 the TARTARUS Model Sensitivity Experiment on a time available basis. The task was completed in March 1975. The TARTARUS model is a firepower potential dependent, ground combat theater model that simulates, at a high level of aggregration, the interactions of combat units in contact. The simulation is achieved through the iterative solution of sets of differential equations which represent the four basic functions: Attrition, Movement Suppression, Fire Suppression Due to Fire, and Fire Suppression Due to Movement.

2. Purpose. - The purpose of the task was to determine what effect changes in input factors have on output factors in the TARTARUS model.

3. Objective. - The objective of the sensitivity experiment was to assess the sensitivity of output variables to the four basic input parameters of the differential equations mentioned above. The output variables chosen were:

a. Red firepower potential (FPP) loss divided by the Blue FPP loss.

b. Average movement by the Blue units.

4. Discussion. - A factorial experiment with each factor having two levels was chosen for the sensitivity analysis. The base case was derived from the data deck used for the TARTARUS version of the base game of the Conceptual Design for the Army in the Field (CONAF) III study for the V Corps sector by changing some unit locations and frontages. Model design, factor inputs, outputs, calculations, problems, and observations are discussed in the paper.

5. Observations. - The TARTARUS model was extremely sensitive to changes in the Movement Suppression Factors; moderately sensitive to changes in the Attrition Factors and the Fire Suppression Due to Fire Factors; and only slightly sensitive to changes in the Fire Suppression Due to Movement Factors. These results were consistent with expectations.

TARTARUS MODEL SENSITIVITY EXPERIMENT

CHAPTER I
INTRODUCTION

1. Background. - The TARTARUS model is a firepower potential dependent, ground combat theater model that simulates, at a high level of aggregation (brigade or division), the interactions of combat units in contact. The simulation is achieved through the iterative numerical solution of sets of differential equations which represent:

a. Attrition.

b. Movement Suppression.

c. Fire Suppression Due to Fire.

d. Fire Suppression Due to Movement.

2. Purpose. - The purpose of the TARTARUS sensitivity experiment was to analytically determine what effect changes in input factors have on output factors in the TARTARUS model.

3. Objective. - The objective of this sensitivity experiment was to assess the sensitivity of output variables to the four input parameters of the differential equations mentioned above. The primary output variables of interest were:

a. The ratio of Red firepower potential (FPP) loss to Blue FPP loss.

b. Average Blue movement.

4. Base Case. - Due to the amount of time and effort involved in setting up a TARTARUS run, it was desirable to use an existing TARTARUS data deck as the base case. The data deck of the TARTARUS version of the base game of the Conceptual Design for the Army in the Field (CONAF) III study for the V Corps sector was modified to generate the base case for the sensitivity experiment. The following modifications were made:

a. The Beginning-of-Period Urit Status File (BOPUSF) for the sensitivity was basically the End-of-Period Unit Status File after 2 days of battle in the CONAF III study.

b. Some unit locations were changed.

c. Some unit frontages were changed.

Fourteen Red divisions were attacking a Blue force of seven brigades in deliberate defense, three brigades in hasty defense, and three brigades in reserve.

5. Experimental Design

a. TARTARUS Inputs. - The four identified input factors were those factors suspected of having the largest influence upon the output factors. The different input values that could be chosen for these four factors were essentially infinite. Therefore, it was decided to choose a value lower and a value higher than that used in the base case for each of the four variables. Thus, the sensitivity experiment involved only the "Low" and "High" levels of each of the four factors.

b. Factorial Experimentation. - In order to maximize the amount of information for a given number of runs, a 2^4 factorial experimental design was chosen. A factorial design is a plan in which each factor under study is tested with each of the other factors at each level of interest. This method also allows information to be obtained on the interaction effect of the factors under study.[1/] A 2^4 design requires 16 model runs to test each factor at each level of the other factors.

c. Mission Inputs. - Since the four factors under study were input by mission, one experiment varied the inputs for the defensive mission with the inputs for the offensive mission held at the base case values. Then for a second experiment, the inputs for the offensive mission were varied while the defensive mission inputs were held at the base case values. For each of the experiments, units of the Blue force were in a defensive mission and units of the Red force were in an attack mission.

d. Other Inputs. - Except for the four factors under study, all other factors were at the base case values. Neither air nor nuclear attacks were played. Units had unlimited supplies but no replacements of equipment or personnel. For each set of conditions, 48 hours of continuous battle was simulated, all under daylight conditions.

[1/] US Army Concepts Analysis Agency, "Application of Statistical Techniques to Model Sensitivity Testing," Technical Paper CAA-TP-74-10, Bethesda, MD, Sep 74.

TARTARUS MODEL SENSITIVITY EXPERIMENT

CHAPTER II
SENSITIVITY ANALYSES

1. Factor Definitions and Inputs. - The four input factor definitions, the base case values, and the assigned Low and High values are given below:

a. Attrition Factors. - The Attrition Factors are used in determining the rate at which a target unit will lose firepower potential (FPP) and personnel. There is one factor for each of the four missions used. (Counterattack and artillery support were not used.) The base case values were multiplied by 0.33 to obtain the Low values and multiplied by 3.0 to obtain the High values. These values are given in Table II-1 (Page II-5).

b. Movement Suppression Factors. - The Movement Suppression Factors are used to determine the reduction in a target unit's unopposed movement rate due to fire received from the three ground fire classes, nuclear strikes, and air strikes. Two of the fire classes (nuclear and air) were not used in these sensitivity runs. There is one factor for each fire class being delivered against units in the four missions. The base case values were multiplied by 0.33 to obtain the Low values. The base case values were multiplied by 2.0 to obtain the High values for classes 1 and 2 and multiplied by 3.0 to obtain the High values for class 3 (Table II-2).

c. Fire Suppression Due to Fire Factors. - The Fire Suppression Due to Fire Factors represent the degradation of unit capability to deliver fire due to fire being received. For each mission there are nine factors, one for each of three ground fire classes against each of the three ground fire classes of the firing unit. The Low values were set to zero and the High values set to 10 except in those cases where it was inappropriate. For example, small arms would not normally suppress artillery fire because small arms would not be in a position to fire on artillery. The base case, Low, and High values are given in Table II-3.

d. Fire Suppression Due to Movement Factors. - The Fire Suppression Due to Movement Factor represent the fraction of degradation of a unit's capability to deliver fire due to its own movement. There is one factor for each fire class for each mission. The Low values were obtained by multiplying the base case values by 0.5. The High values were obtained by multiplying the base case values by 1.1 (Table II-4).

2. Analyses

a. First Sensitivity Runs. - In the first experiment, changes were made to the factors of the defending (Blue) units. The first sensitivity run had all four input variables set at the Low values. Problems arose in this first run. Some Red units overran some Blue units and then moved swiftly to the rear of the Blue supporting units. That is, the Blue units could not move back as fast as the Red units were moving forward. Thus, it was only a matter of time before the Red units overtook and passed the Blue units. It was suspected that the Movement Suppression Factor were causing the problem. To verify this suspicion, the Movement Suppression Factors were changed back to the base case values (Table II-2). With the Movement Suppression Factors set at the base case values and the other three factors set at the Low values, there was no problem. The Red and Blue units moved along together with no overruns. From the analysis of these two runs it was deduced that the Movement Suppression Factors had been reduced to an unreasonable value. Thus the process of determining a reasonable value was begun. After several attempts it was learned that these values could only be reduced by 0.25 and still have proper movement. That is, it was concluded that the Movement Suppression Factors were extremely sensitive to change.

b. Design Change. - Since it was determined that the TARTARUS Model was extremely sensitive to changes in the Movement Suppression Factors, the decision was made that the Movement Suppression Factors would not be subjected to further sensitivity testing. The Movement Suppression Factors were reset to the base case values. With only three factors remaining in the sensitivity experiment, the design was changed to a 2^3 factorial design. Making changes in only three factors, three successful runs were completed before another problem surfaced. In the fourth run, all three factors were set at the High values, with the Fire Suppression Due to Fire Factors being at the High value for the first time. In this fourth run, the Red units overran the Blue units again. In the TARTARUS Players Manual[2/] the Fire Suppression Due to Fire Factors are defined as follows: "These factors represent the degradation, by percent, of a unit's capability to deliver fire due to fire being received." However, after checking the programing code of the model it was learned that these factors were not by "percent" but multiplication factors or weighting factors. Knowing that the Fire Suppression Due to Fire Factors were weighting factors, it was then realized that the High values being used (all 10.0) were too high. The High values were then changed to 1.3 times the base case values

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[2/] US Army Strategy and Tactics Analysis Group, "TARTARUS IV N/COCO, Players and Technical Manual," Bethesda, MD.

(Table II-5). However, the problem of the Red units overrunning the Blue units remained. To correct this problem, 1.0 was added to the base case values of the defending missions of the Movement Suppression Factors (Table II-6). The base case, all previous runs, and the remainder of the runs were made using the values given in Tables II-1, II-4, II-5, and II-6.

c. Data. - The data from the runs with factor level changes to the defending (Blue) units are given in Tables II-7 and II-8. The data in Table II-7 are the Red FPP loss divided by the Blue FPP loss. The data in Table II-8 are averages of the cumulative distances, in hectometers, Blue units have moved since the start of the game. The Blue units in reserve that did not move were not included in the averages. Similar data from the runs with factor level changes to the attacking (Red) units are given in Tables II-9 and II-10.

d. Factor Effect Calculations. - The TARTARUS model is a deterministic model. Consequently, no uncontrolled variation was available for estimating an error variance. For this reason the significance of input factors was not assessed by statistical tests such as analysis of variance (ANOVA). Instead, significance of input factors was assessed by judgmental comparative analysis of the effect of the change in input factors upon the output variable. All eight output values are used in the estimation of each factor and interaction effect. The best estimate of the effect of changing the input variable Attrition from the Low level to the High level upon the output variable Red FPP loss/Blue FPP loss is the difference between the averages of the four output values at the High level and the average of the four output values at the Low level. For example, the two averages of the data in Table II-7 for the High and Low Attrition levels, respectively, are:

$$(1.6 + 1.6 + 1.5 + 1.5)/4 = 1.5$$

$$(13.9 + 13.9 + 12.9 + 12.8)/4 = 13.4$$

This difference (1.5 - 13.4 = -11.9) reflects the sensitivity of the ratio of the Red FPP loss to the Blue FPP loss to the change from High Attrition values to Low Attrition values. The same procedures were used to compute the averages and differences for the other two factors and the other output variables. The averages and the differences are given in Tables II-11 and II-12 for the factor level changes to the defending units and attacking units, respectively.

e. Interaction Effect Calculations. - The sensitivity experiment was designed in a manner that would permit the assessment of

interaction effects. Interactions between two factors are important because judgments about either one of the factors are dependent upon the level of the other factor. That is, inferences about either individual factor are meaningless if the two factors interact. The analysis of interactions is illustrated below for the Attrition Factor (A) and Fire Suppression Due to Fire Factor (B) interaction, AB. An "L" indicates that a factor is at the Low level and an "H" indicates that a factor is at the High level (Table II-7).

$$\overline{A_H B_H} = (HHL + HHH)\ /2 = (1.5 + 1.5)/2 = 1.5$$

$$\overline{A_H B_L} = (HLL + HLH)/2 = (1.6 + 1.6)/2 = 1.6$$

$$\overline{A_L B_H} = (LHL + LHH)/2 = (12.9 + 12.8)/2 = 12.8$$

$$\overline{A_L B_L} = (LLL + LLH)/2 = (13.9 + 13.9)/2 = 13.9$$

Then, the change in factor B when factor A is at the High level is:

$$(\overline{A_H B_H} - \overline{A_H B_L}) = (1.5 - 1.6) = -0.1$$

The change in factor B when factor A is at the Low level is:

$$(\overline{A_L B_H} - \overline{A_L B_L}) = (12.8 - 13.9) = -1.1$$

The difference in these two changes is: (-0.1 + 1.1) equals 1.0. This difference is a measure of the interaction between factors A and B. The AC and BC interaction effects were calculated in a similar manner and are given in Tables II-13 and II-14.

f. Graphical Illustration of Effects. - The factor effects are graphically illustrated for the main effects in Figures II-1 through II-4. The greater the slope of the line, the greater the effect of changing the factor level from Low to High. The factor interaction effects are graphically illustrated in Figures II-5 through II-8. The greater the departure from parallelism of a pair of lines, the larger the interaction between the two variables.

TABLE II-1, Attrition Factors

Mission	Low	Base Case	High
Prepared defense	0.0023	0.007	0.021
Attack	0.0103	0.031	0.093
Hasty defense	0.0033	0.010	0.030
Delay	0.0020	0.006	0.018

TABLE II-2, Movement Suppression Factors

Mission	Suppressing fire class	Low	Base Case	High
Prepared defense	1	4.37	13.10	26.20
	2	4.37	13.10	26.20
	3	1.13	3.40	20.20
Attack	1	12.00	36.00	72.00
	2	12.00	36.00	72.00
	3	3.00	9.00	27.00
Hasty defense	1	4.20	12.60	25.20
	2	4.20	12.60	25.20
	3	1.05	3.15	6.30
Delay	1	5.41	16.24	32.48
	2	5.41	16.24	32.48
	3	1.35	4.06	8.12

TABLE II-3, Fire Suppression Due to Fire Factors

Mission	Suppressing fire class								
	1			2			3		
	Suppressed fire class			Suppressed fire class			Suppressed fire class		
	1	2	3	1	2	3	1	2	3
Prepared defense									
Low	0	0	0	0	0	0	0	0	0
Base Case	1.5	1.0	0	1.0	1.0	0	1.5	1.0	2.0
High	10.0	10.0	0	10.0	10.0	0	10.0	10.0	10.0
Attack									
Low	0	0	0	0	0	0	0	0	0
Base Case	4.0	1.5	0	4.0	3.0	0	4.0	3.0	3.0
High	10.0	10.0	0	10.0	10.0	0	10.0	10.0	10.0
Hasty defense									
Low	0	0	0	0	0	0	0	0	0
Base Case	1.5	1.0	0	1.0	1.0	0	1.5	1.0	1.5
High	10.0	10.0	0	10.0	10.0	0	10.0	10.0	10.0
Delay									
Low	0	0	0	0	0	0	0	0	0
Base Case	1.5	1.0	0	1.0	1.0	0	1.5	1.0	2.0
High	10.0	10.0	0	10.0	10.0	0	10.0	10.0	10.0

TABLE II-4, Fire Suppression Due to Movement Factors

Mission	Firing unit fire class	Low	Base Case	High
Prepared defense	1	0.415	0.830	0.913
	2	0.055	0.110	0.121
	3	0.055	0.110	0.121
Attack	1	0.420	0.840	0.924
	2	0.190	0.380	0.418
	3	0.190	0.380	0.418
Hasty defense	1	0.425	0.850	0.935
	2	0.185	0.370	0.407
	3	0.185	0.370	0.407
Delay	1	0.470	0.940	1.034
	2	0.275	0.550	0.605
	3	0.375	0.750	0.825

TABLE II-5, Adjusted Fire Suppression Due to Fire Factors

Mission	Suppressing fire class								
	1			2			3		
	Suppressed fire class			Suppressed fire class			Suppressed fire class		
	1	2	3	1	2	3	1	2	3
Prepared defense									
Low	0	0	0	0	0	0	0	0	0
Base Case	1.50	1.00	0	1.00	1.00	0	1.50	1.00	2.00
High	1.95	1.30	0	1.30	1.30	0	1.95	1.30	2.60
Attack									
Low	0	0	0	0	0	0	0	0	0
Base Case	4.00	1.50	0	4.00	3.00	0	4.00	3.00	3.00
High	5.20	1.95	0	5.20	3.90	0	5.20	3.90	3.90
Hasty defense									
Low	0	0	0	0	0	0	0	0	0
Base Case	1.50	1.00	0	1.00	1.00	0	1.50	1.00	1.50
High	1.95	1.30	0	1.30	1.30	0	1.95	1.30	1.95
Delay									
Low	0	0	0	0	0	0	0	0	0
Base Case	1.50	1.00	0	1.00	1.00	0	1.50	1.00	2.00
High	1.95	1.30	0	1.30	1.30	0	1.95	1.30	2.60

TABLE II-6, Adjusted Movement Suppression Factors

Mission	Suppressing fire class	Base Case
Prepared defense	1	14.10
	2	14.10
	3	4.40
Attack	1	36.00
	2	36.00
	3	9.00
Hasty defense	1	13.60
	2	13.60
	3	4.15
Delay	1	17.24
	2	17.24
	3	5.06

TABLE II-7, Red FPP Loss Divided by Blue FPP Loss
(Factor Level Changes to Defending Units)

Factor A - Attrition	Factor B - Fire Suppression Due to Fire			
	Low values (0.0)		High values (1.3 base case)	
	Factor C - Fire Suppression Due to Movement		Factor C - Fire Suppression Due to Movement	
	Low values (base case/2)	High values (11/10 base case)	Low values (base case/2)	High values (11/10 base case)
Low values (base case/3)	LLL 27.16/1.95 = 13.9	LLH 27.02/1.95 = 13.9	LHL 25.05/1.94 = 12.9	LHH 24.78/1.94 = 12.8
High values (3 x base case)	HLL 25.12/15.82 = 1.6	HLH 24.87/15.79 = 1.6	HHL 23.50/15.82 = 1.5	HHH 23.22/15.82 = 1.5

TABLE II-8, Average Blue Movement (Hectometers)
(Factor Level Changes to Defensive Units)

Factor A - Attrition	Factor B - Fire Suppression Due to Fire			
	Low values (0.0)		High values (1.3 base case)	
	Factor C - Fire Suppression Due to Movement		Factor C - Fire Suppression Due to Movement	
	Low values (base case/2)	High values (11/10 base case)	Low values (base case/2)	High values (11/10 base case)
Low values (base case/3)	70.7	80.2	156.7	173.0
High values (3 x base case)	151.2	165.4	207.5	227.8

TABLE II-9, Red FPP Loss Divided by Blue FPP Loss
(Factor Level Changes to Attacking Units)

Factor A - Attrition	Factor B - Fire Suppression Due to Fire			
	Low values (0.0)		High values (1.3 base case)	
	Factor C - Fire Suppression Due to Movement		Factor C - Fire Suppression Due to Movement	
	Low values (base case/2)	High values (11/10 base case)	Low values (base case/2)	High values (11/10 base case)
Low values (base case/3)	8.69/6.38 = 1.4	8.71/6.23 = 1.4	8.77/5.86 = 1.5	8.79/5.71 = 1.5
High values (3 x base case)	63.48/5.73 = 11.1	63.55/5.67 = 11.2	63.87/5.32 = 12.0	63.95/5.25 = 12.2

TABLE II-10, Average Blue Movement (Hectometers)
(Factor Level Changes to Attacking Units)

Factor A - Attrition	Factor B - Fire Suppression Due to Fire			
	Low values (0.0)		High values (1.3 base case)	
	Factor C - Fire Suppression Due to Movement		Factor C - Fire Suppression Due to Movement	
	Low values (base case/2)	High values (11/10 base case)	Low values (base case/2)	High values (11/10 base case)
Low values (base case/3)	192.1	189.9	186.9	186.4
High values (3 x base case)	95.7	94.9	90.9	89.8

TABLE II-11, Factor Effects When Factor Level Changes Were Applied to Defending Units

Average Red FPP Loss/Blue FPP Loss			
Factor	Average		Difference (High minus Low)
	Low	High	
Attrition	13.4	1.5	-11.9
Fire Suppression Due to Fire	7.7	7.2	-0.5
Fire Suppression Due to Movement	7.5	7.4	-0.1
Average Blue Movement (Hectometers)			
Factor	Average		Difference (High minus Low)
	Low	High	
Attrition	120.1	188.0	67.9
Fire Suppression Due to Fire	116.9	191.3	74.4
Fire Suppression Due to Movement	146.5	161.6	15.1

TABLE II-12, Factor Effects When Factor Level Changes Were Applied to Attacking Units

Average Red FPP Loss/Blue FPP Loss			
Factor	Average		Difference (High minus Low)
	Low	High	
Attrition	1.4	11.6	10.2
Fire Suppression Due to Fire	6.3	6.8	0.5
Fire Suppression Due to Movement	6.5	6.6	0.01
Average Blue Movement (Hectometers)			
Factor	Average		Difference (High minus Low)
	Low	High	
Attrition	188.9	92.8	-96.1
Fire Suppression Due to Fire	143.2	138.5	-4.7
Fire Suppression Due to Movement	141.4	140.3	-1.1

TABLE II-13, Interaction Effects (Factor Level Changes to Defending Units)

Interaction	Output variable	
	Red FPP loss/ Blue FPP loss	Average Blue movement
AB	+1.0	-30.0
AC	+0.1	+4.3
BC	0.0	+6.5

A - Attrition Factors

B - Fire Suppression Due to Fire Factors

C - Fire Suppression Due to Movement Factors

TABLE II-14, Interaction Effects (Factors Level Changes to Attacking Units)

Interaction	Output variable	
	Red FPP loss/ Blue FPP loss	Average Blue movement
AB	+0.8	-0.6
AC	+0.1	+0.4
BC	0.0	+0.6

A - Attrition Factors

B - Fire Suppression Due to Fire Factors

C - Fire Suppression Due to Movement Factors

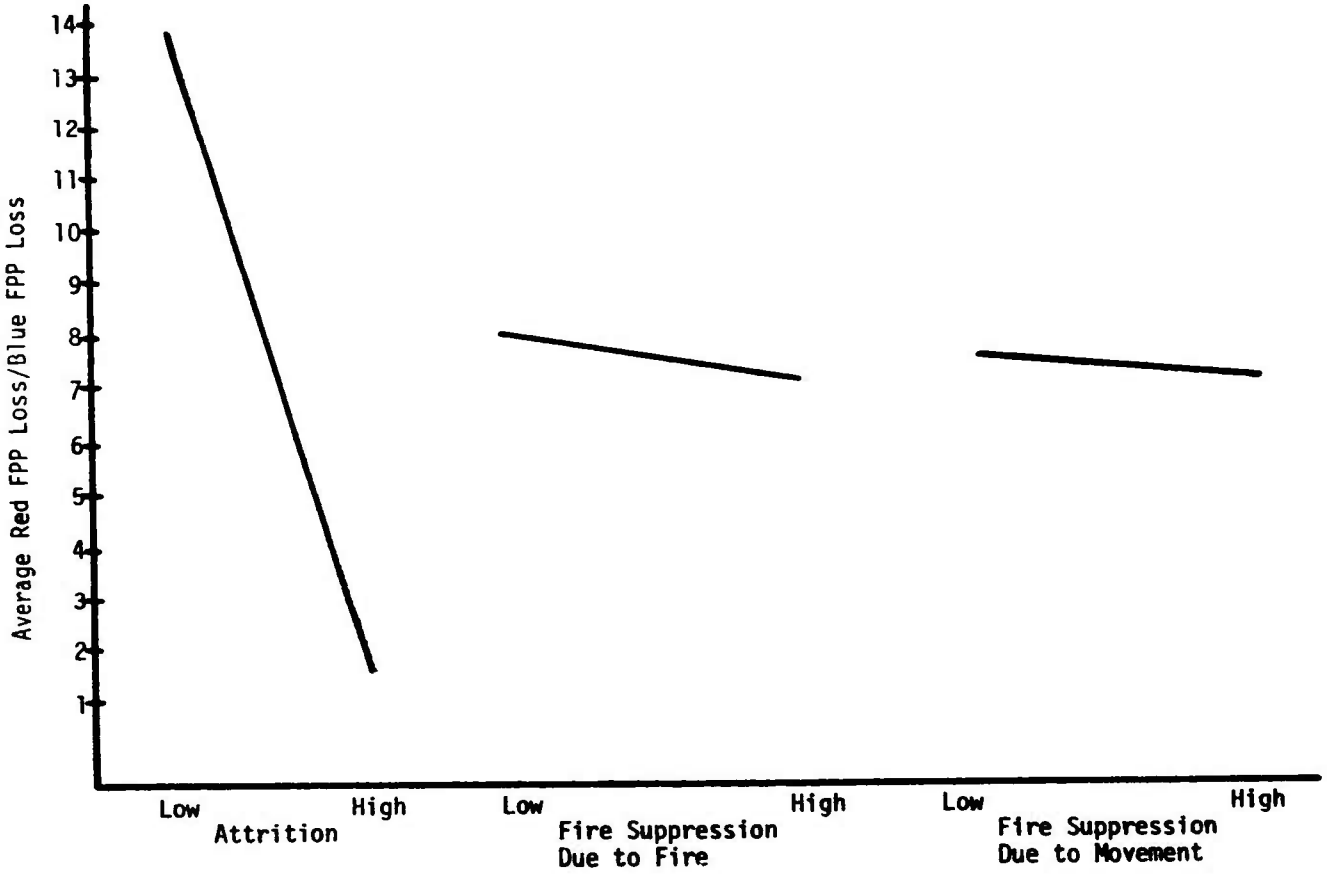

FIGURE II-1, Factor Effects of Average Red FPP Loss/Blue FPP Loss
(Factor Level Changes to Defending Blue Units)

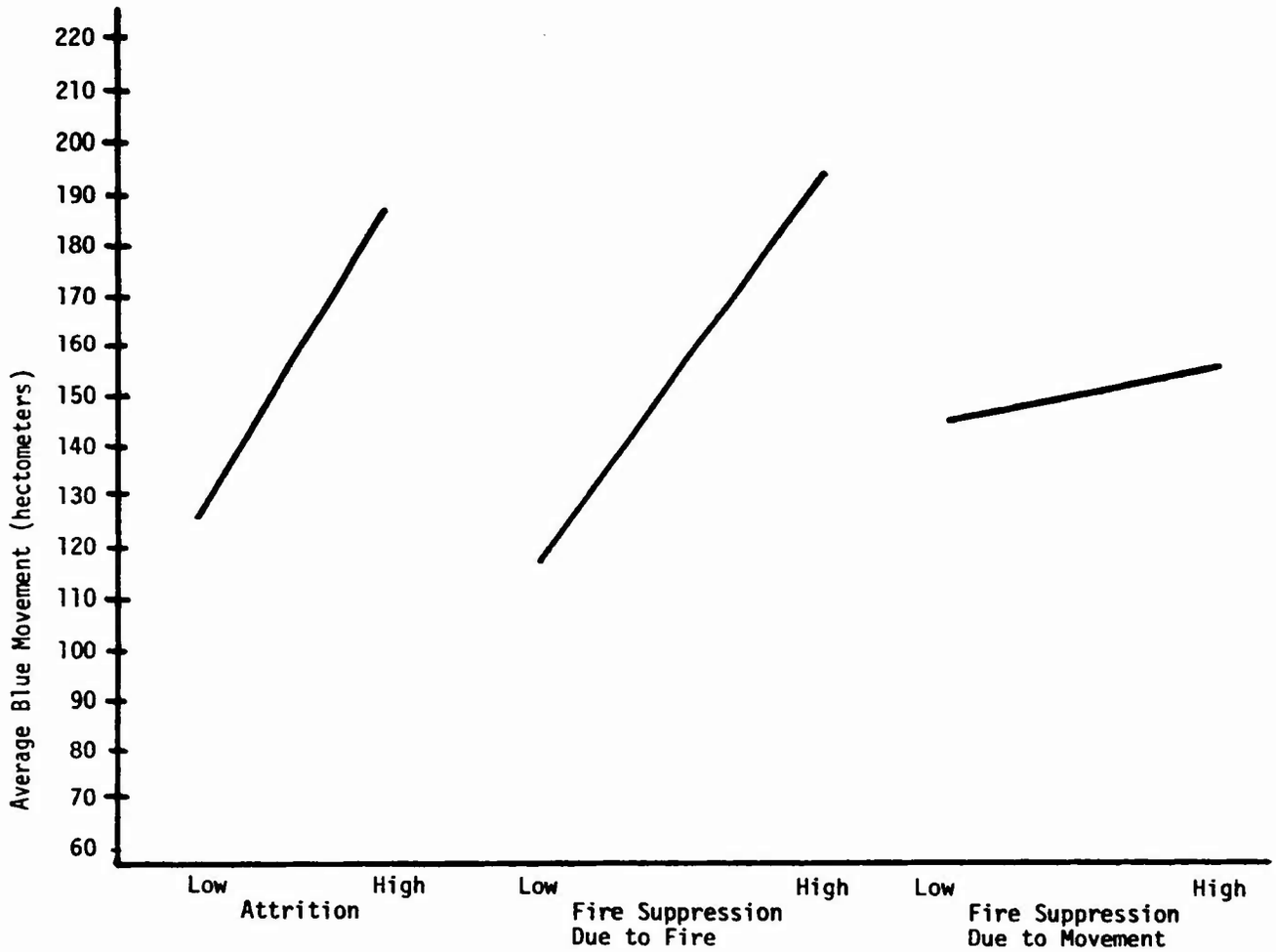

FIGURE II-2, Factor Effects of Average Blue Movement
(Factor Level Changes to Defending Blue Units)

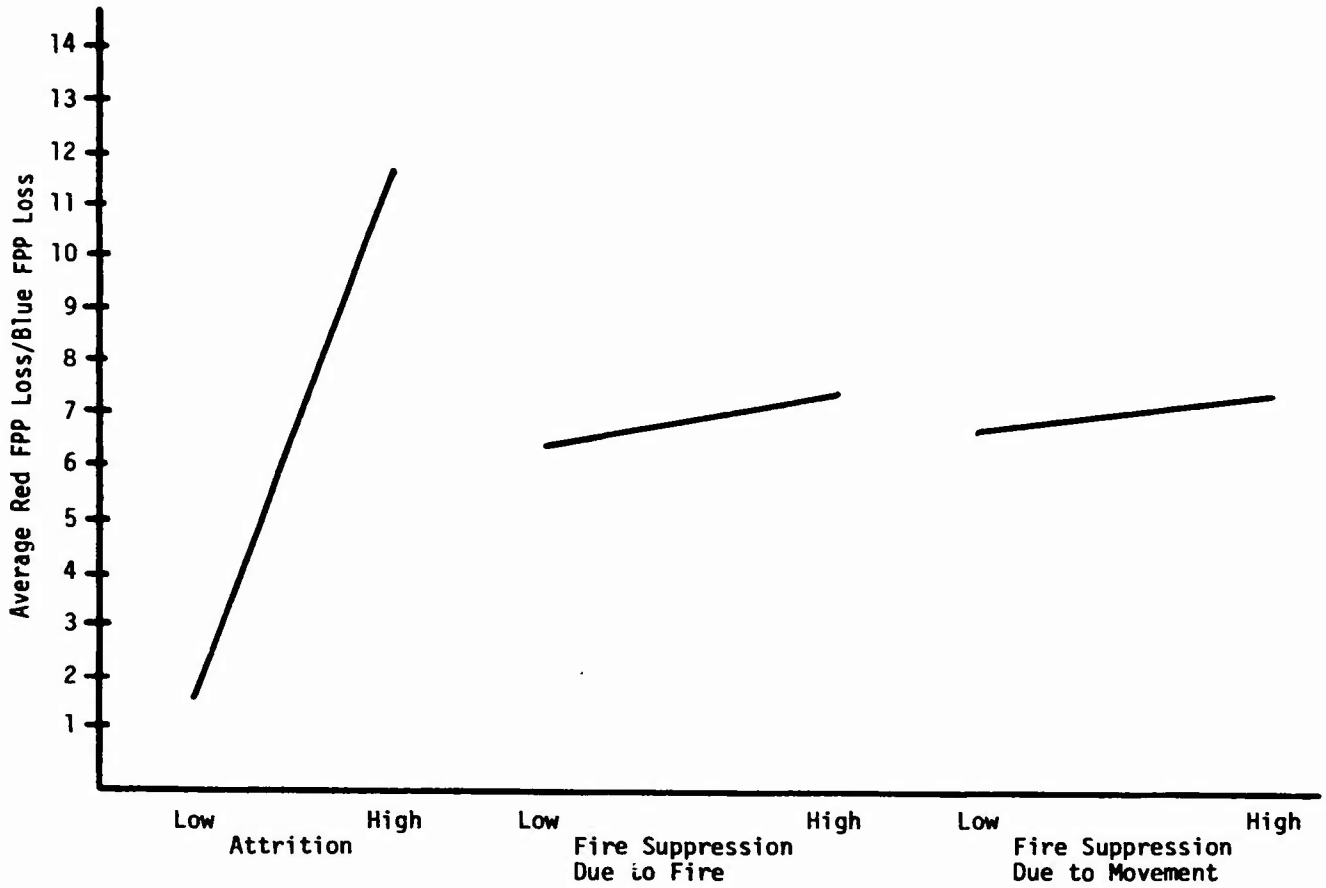

FIGURE II-3, Factor Effects of Average Red FPP Loss/Blue FPP Loss
(Factor Level Changes to Attacking Red Units)

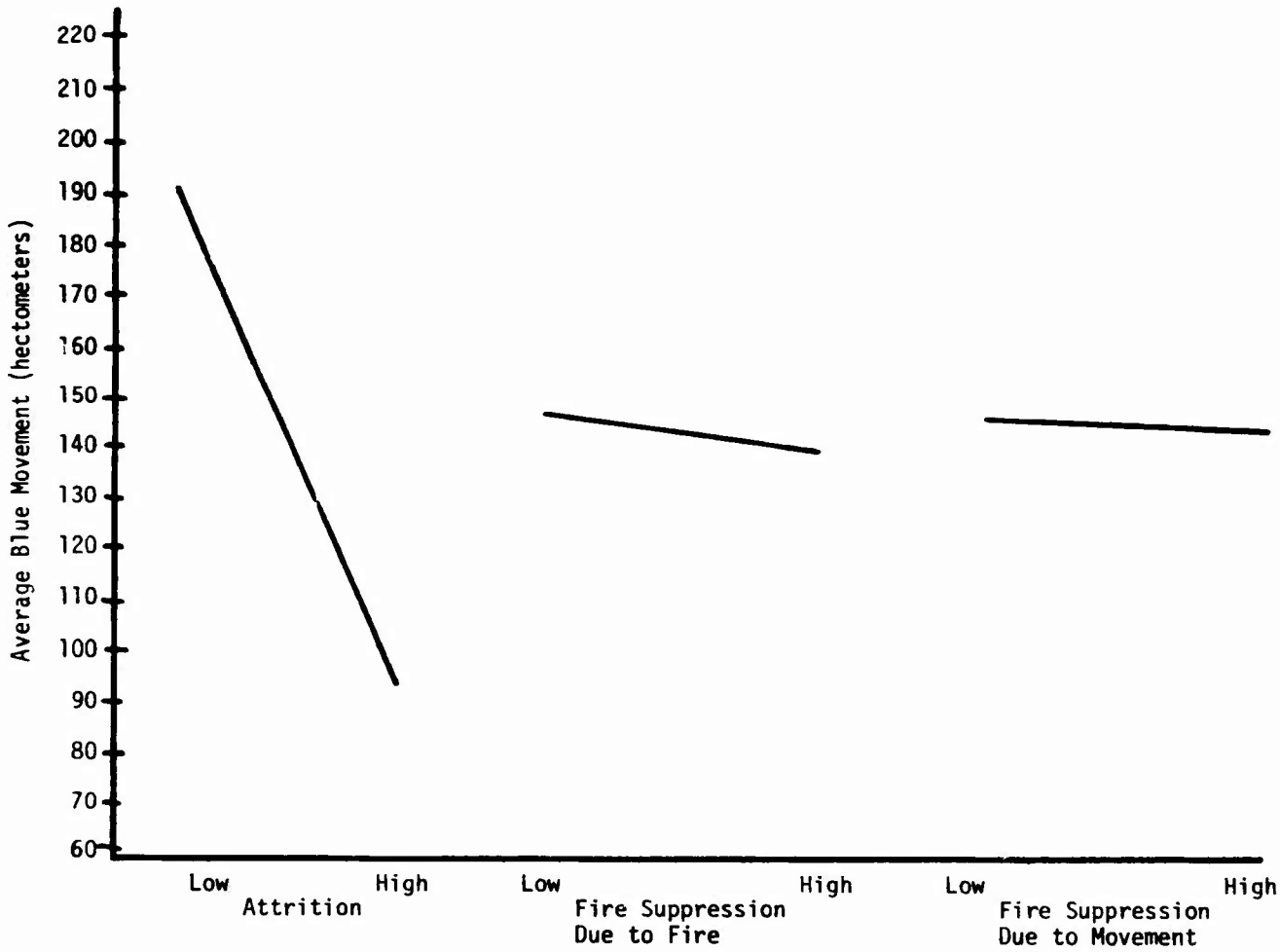

FIGURE II-4, Factor Effects of Average Blue Movement
(Factor Level Changes to Attacking Red Units)

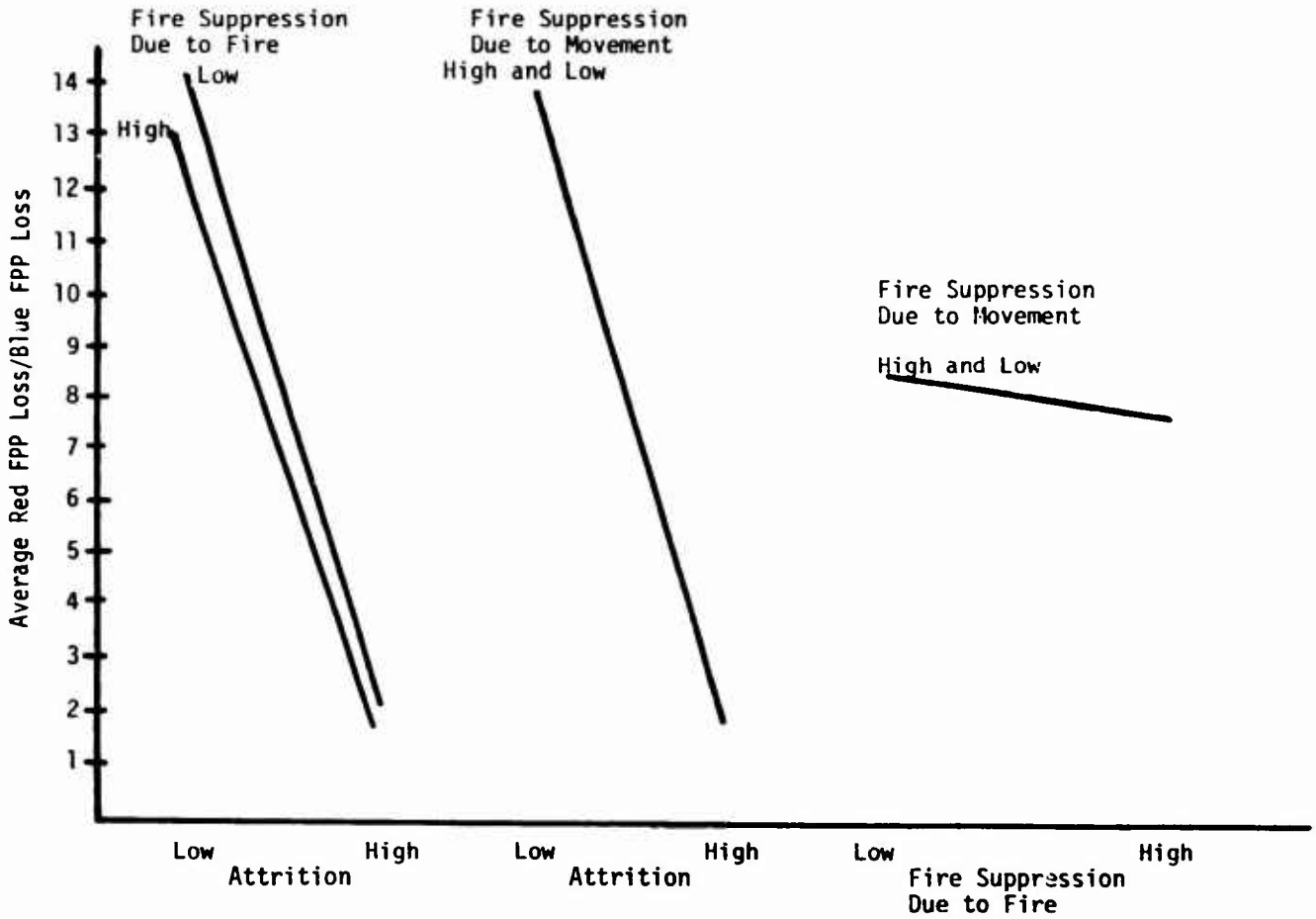

FIGURE II-5, Average Red FPP Loss/Blue FPP Loss Interaction Effects
(Factor Level Changes to Defending Blue Units)

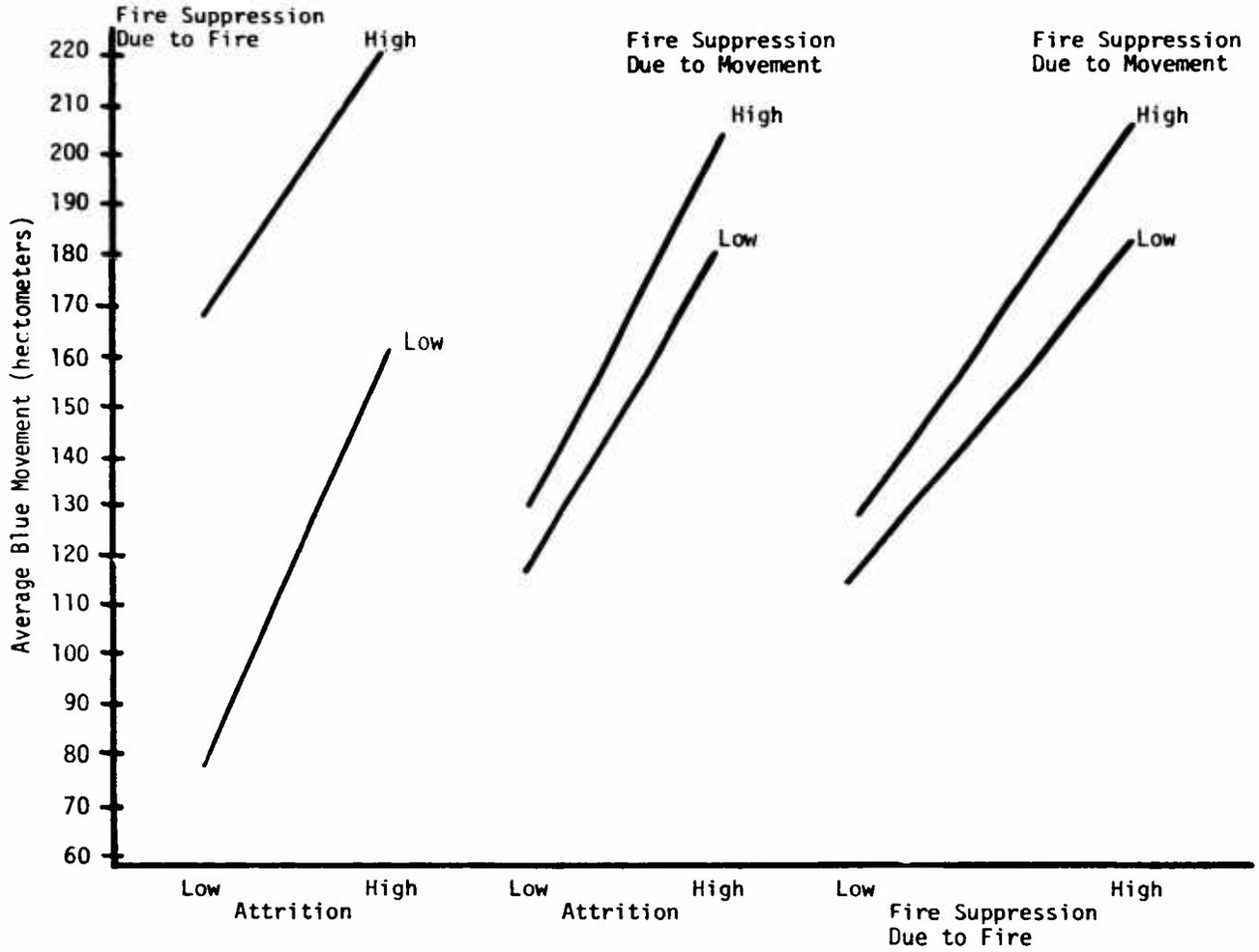

FIGURE II-6, Average Blue Movement Interaction Effects
(Factor Level Changes to Defending Blue Units)

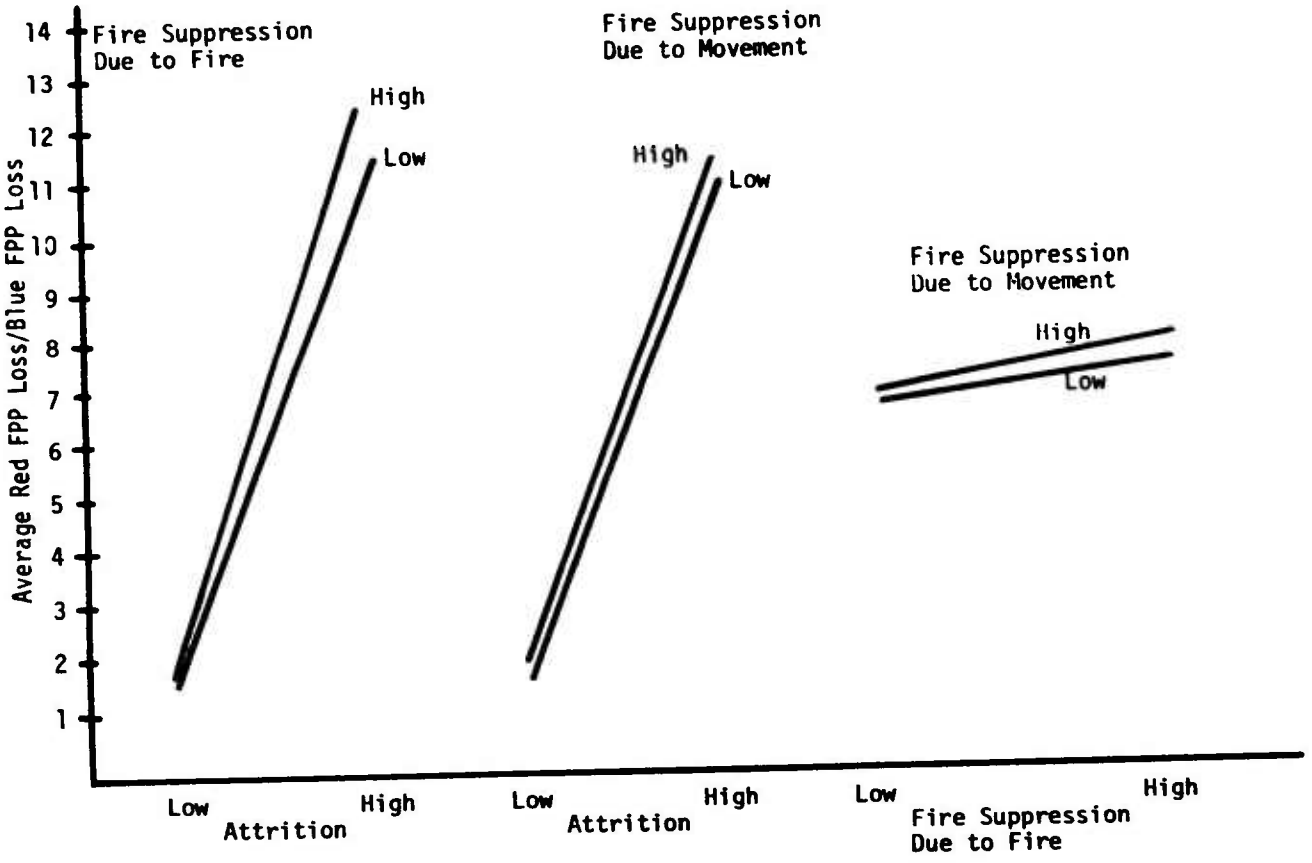

FIGURE II-7, Average Red FPP Loss/Blue FPP Loss Interaction Effects (Factor Level Changes to Attacking Red Units)

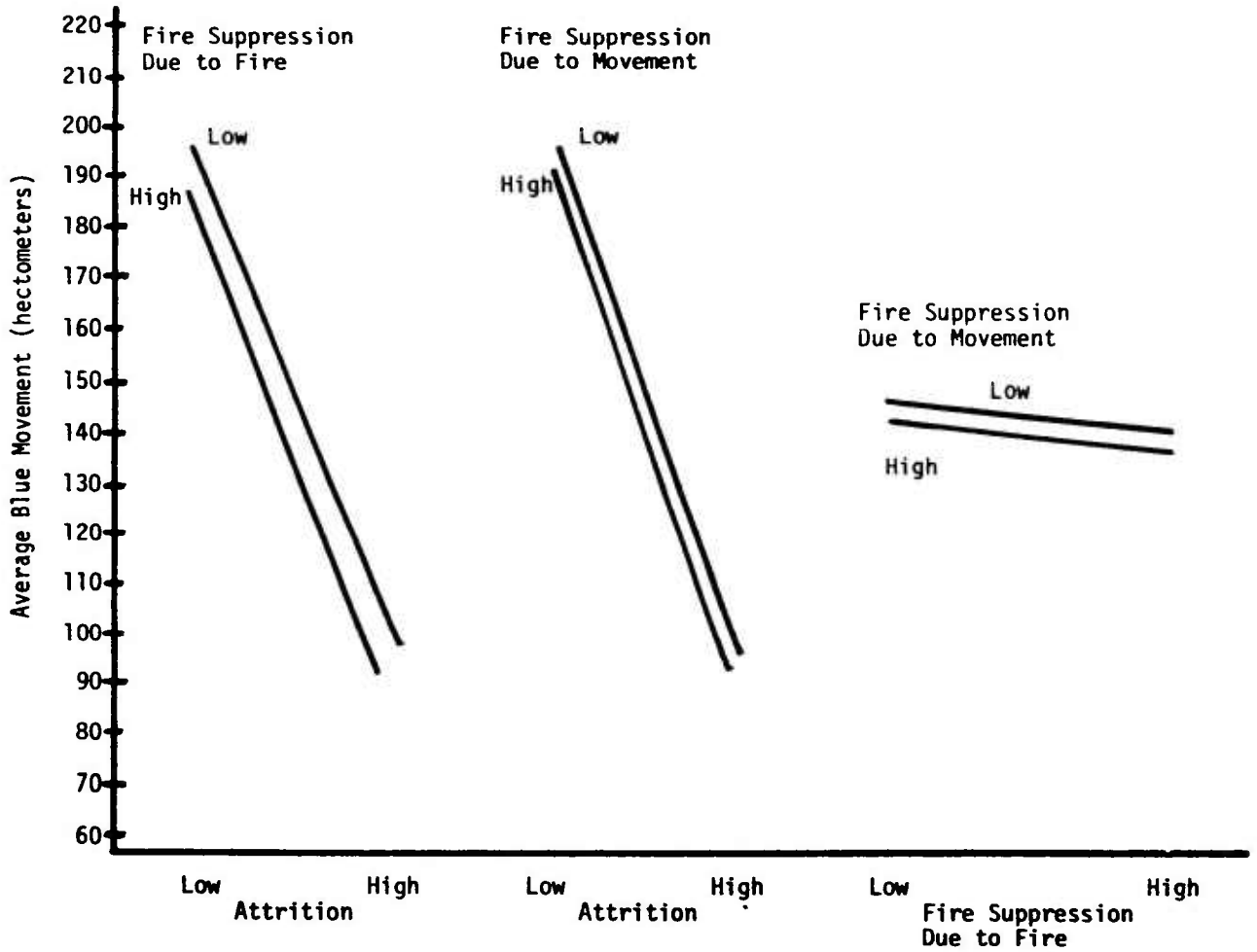

FIGURE II-8, Average Blue Movement Interaction Effects
(Factor Level Changes to Attacking Red Units)

TARTARUS MODEL SENSITIVITY EXPERIMENT

CHAPTER III
OBSERVATIONS

1. Judgmental Comparative Assessment of Output Data. - Since TARTARUS is a deterministic model, the significance of output variable(s) differences could not be statistically assessed. Thus, a judgmental comparative assessment was performed on the output variable(s) differences. Analyses were performed on the average Red FPP loss/Blue FPP loss and average Blue movement. On the basis of the above data analyses, the following observations are stated:

a. Average Red FPP Loss/Blue FPP Loss

(1) Average Red FPP loss/Blue FPP loss was considered sensitive to changes of the Attrition Factors from Low values of one-third of the base case values to High values of three times the base case values. When factor level changes were made to the defending units (Blue), Blue units lost less FPP when the Attrition Factors were at the Low level, thereby making the loss ratio larger. When the Attrition Factors were at the High level, the ratio became smaller. When factor level changes were made to the attacking units (Red), the reverse was true. (See Tables II-7, II-9, II-11 and II-12.)

(2) The average Red FPP loss/Blue FPP loss was rather insensitive to changes in the Fire Suppression Due to Fire Factors and the Fire Suppression Due to Movement Factors in either experiment. (See Tables II-11 and II-12.)

(3) The average Red FPP loss/Blue FPP loss data exhibited no interaction effect among the variables in either experiment. (See Tables II-13 and II-14.)

b. Average Blue Movement

(1) When factor level changes were made to the defending units, the average Blue movement was sensitive to changes in the Attrition Factors and the Fire Suppression Due to Fire Factors. However, when factor level changes were made to the attacking units, the average Blue movement was sensitive to only changes in the Attrition Factors. (See Tables II-11 and II-12.) In other words, the average Blue movement was dependent upon the level at which Blue Fire Suppression Due to Fire Factors were set, but was not dependent upon the level at which Red Fire Suppression Due to Fire Factors were set. Examination of TARTARUS movement logic revealed that this result was to be expected.

(2) Average Blue movement was rather insensitive to changes in the Fire Suppression Due to Movement Factors when factor level changes were applied to the defending units. When factor level changes were applied to the attacking units, average Blue movement was rather insensitive to changes in the Fire Suppression Due to Fire Factors and the Fire Suppression Due to Movement Factors. (See Tables II-11 and II-12.)

(3) Although the AB interaction effect (Attrition x Fire Suppression Due to Fire) is larger than the other two interaction effects, the average Blue movement is not considered to be sensitive to this effect. (See Tables II-13 and II-14.)

2. Summary of Analyses Results. - Analyses results of the sensitivity study of the four input factors indicated that the TARTARUS model output was extremely sensitive to factor level changes in the Movement Suppression Factors; moderately sensitive to changes in the Attrition and Fire Suppression Due to Fire Factors; and only slightly sensitive to changes in the Fire Suppressior Due to Movement Factors. The TARTARUS model was only slightly sensitive to the Fire Suppression Due to Movement Factors because of the slow movement in the model. Analysis revealed that the opposed movement rate in the situation gamed was approximately 10 percent of the unopposed rate. Hence, a change in the Fire Suppression Due to Movement Factors changed a number that was already very small and had little impact on losses or movement. Since it is expected that the TARTARUS movement rates will generally be slow, Fire Suppression Due to Movement Factors will generally have little impact on losses or movement. However, in a game where units are moving rapidly (relatively unopposed), the results would be sensitive to these Fire Suppression Due to Movement Factors. Thus, it can be stated that all the output effects were in the proper direction and of the magnitude expected.

APPENDIX A

STUDY CONTRIBUTORS

TARTARUS MODEL SENSITIVITY EXPERIMENT

APPENDIX A
STUDY CONTRIBUTORS

STUDY TEAM

1. Study Director

   Jerry Thomas, Methodology and Resources Directorate

2. Team Members

   David Howes, Methodology and Resources Directorate

   George Maerz, Project Planning and Control Office

3. Support Personnel

   Linda L. Prieto

   Carol S. Martin

   Thelma L. Laufer

PRODUCT REVIEW BOARD

Bennie L. Robbins, War Gaming Directorate, Chairman

Patricia Fleming, Methodology and Resources Directorate

Manfred Leiser, Systems Integration Analysis Directorate